large number occurred on the 1st and 2d, and from the 11th to the close of the month they were general. The larger number occurred in the mountainous country and in the basin and plateau region to the eastward of the Cascade Range. More than 40 stations in the State of Oregon alone reported one or more thunderstorms.

Killing frosts occurred at over a dozen stations in Oregon, and light to heavy frosts at a good many more points in Washington and Idaho. Damage was not general, however, being confined to limited areas.

Sunshine was deficient in Washington, particularly west of the Cascade Mountains. It was somewhat below normal in northwestern Oregon, but elsewhere in the district there was about the usual amount.

The average wind direction was from the west, and the highest velocity reported was 56 miles an hour from the southeast at North Head, Wash., on the 14th.

WATER RESOURCES IN OREGON AND THEIR DEVELOPMENT.

By JOHN T. WHISTLER, Member American Society of Civil Engineers.

A prominent man in public affairs said recently with reference to certain of our country's natural resources: "There is but one protection—an awakened public opinion. That is why I give you the facts."

It is certainly very true that if we are to make the most of our natural resources there must be a wide general knowledge of what they are and the conditions surrounding them.

More than six years ago I had the privilege of conveying to the joint committee on irrigation of the Oregon State Legislature, then in session, the offer of the Director of the United States Geological Survey to allot, from the Federal appropriation for stream-gaging work, an amount equal to whatever the State legislature would appropriate for the same purpose, not exceeding $25,000 per annum; that is, if the State would appropriate $25,000 for stream-gaging work in Oregon, the United States Geological Survey would allot from the Federal appropriation a similar amount, making $50,000 per annum for stream-gaging work.

Other States, more keenly alive to the value of such work, promptly accepted similar offers, and it is not now so easy to get the full amount originally offered.

What the State legislature actually did, was to appropriate only 10 per cent of the full amount offered, or $2,500. The United States Geological Survey, true to its offer, allotted an equal amount each year. This year, as a result of the continued agitation, the State legislature appropriated a total of $25,000 for hydrographic and topographic work, about $10,000 of which goes to stream-gaging work. The United States Geological Survey has allotted a similar amount.

QUANTITY OF WATER AS AFFECTING IRRIGATION, WATER-POWER DEVELOPMENT, AND NAVIGATION.

Taking up the features of water resources having more direct reference to quantity. I wish to show the short-sightedness displayed in developing a knowledge of what the resources of this character are in the State of Oregon.

About the first things an engineer must consider in either an irrigation or a water-power project are, What are the mean daily discharges, what is the minimum discharge and its duration, and what is the maximum rate of discharge that will have to be taken care of. The latter will not be determined by 10 or 25 years' records, or even a 100-year record, as witnessed in the recent flood of the river Seine in France. Such reports will be of value, though, in aiding to form a judgment of what it may be. The mean daily discharges, however, and the probable yearly variation from them in the future, will be fairly well known, and this can not be even reasonably determined in any other way.

It makes no difference how valuable such information would be to the State of Oregon, directly or indirectly, to-day or to-morrow, concerning some stream of which such gagings and records have not been made and kept, no amount of money can obtain them now. It costs very little money as compared to its value, but it requires years of time.

I can call to mind irrigation projects which would involve the expenditure of many millions in construction in Oregon, but which can not be financed at the present time because of the very meager knowledge of the available water supply. The same can be said of power projects. If the people generally could only realize the value of this knowledge I feel the demand for a still larger appropriation by the legislature would be such as to make it one of the first acts of the next session.

The value of this knowledge of stream flow is not alone in connection with the development of new projects, but it is also in the better and more equitable distribution of existing water rights. Last year my attention was called to a news item from Roswell, N. Mex., in which it was stated that since the completion of the Hondo project by the Reclamation Service some two years prior, the reservoir had not received a drop of run-off. I understand that this was true, and that practically the same conditions have continued to the present time.

The Sweetwater Dam in southern California was completed to a height of 95 feet in 1895. It created a storage reservoir of 22,500 acre-feet capacity. During the eight years prior to this the run-off at the dam had averaged nearly this amount, though over two-fifths of it ran off in one year. The total run-off for the next nine years was less than half enough to fill the reservoir once, and probably barely supplied evaporation. During four of these years there was absolutely no run-off at the dam, and three of these years were successive.

After 10 years, during which the total run-off was not sufficient to fill the reservoir once, the supply has again been abundant, and the dam this year has again been increased by sufficient to approximately double the capacity of the reservoir. This is practically the fourth time the dam has been increased, yet there is little doubt that if a better knowledge had been available of the stream's characteristics the dam would never have been commenced.

The feeling is yet prevalent with most Oregonians that irrigation in the Willamette Valley would be like "carrying coals to Newcastle," but it is a fact that the average precipitation in this valley during the growing season is less than in many of the arid regions. This is well illustrated in the diagram, Fig. 1, compiled from the records of the United States Weather Bureau and published by the Oregon Conservation Commission, which has undertaken to promote irrigation in the Willamette Valley.

A knowledge of water resources is not complete when we have made analyses of the character of all our waters and have obtained long records of rate of discharge, as we also want to know what can be done to increase the minimum discharge of a stream. This is as true for power development as for irrigation. The minimum flow of a stream usually determines the maximum economic development of a power project, because a power good for only nine months in the year has little demand, and the instal-

lation of auxiliary steam plants to supply the deficiency during the three months adds so much to the yearly cost of the power in the way of interest, depreciation, insurance, and operation, as well as for fuel, that a power plant of this character can not usually compete with one not requiring an auxiliary plant.

The diversion of water from a stream is almost invariably so interrelated with other uses of water from the same stream, either present or future, that economic development of our water resources requires that each new use of water proposed, whether by diversion alone or by storage and diversion both, be considered in connection with all other possible uses of water from the same stream before the right is granted to construct. This is precisely what is done now in all the older countries where irrigation is practiced, such as Italy, France, and Spain.

To illustrate: If the irrigation interests of a valley or drainage basin appear, after a thorough consideration, to be superior to power interests—that is, of more value to the State—the granting of a power right on the stream below the irrigation lands should only be done as inferior to all subsequent diversions above for irrigation. If, on the other hand, after full consideration and with all the data essential to such consideration and study, it appears that the stream is more valuable for power purposes, then diversion for irrigation should be made inferior to power diversions.

If this is not done we may see the spectacle of a power plant worth, say, $1,000,000, on the lower course of a stream, holding up irrigation development above worth many millions. Even if the power right be condemned and the owners fully compensated for all expenditures and all values of the site as a power site, it will, nevertheless, have been an economic waste.

It will be said by some, "Let the fellow who gets there first have it. 'Finding is having.'" Now the facts are that the value of all water rights is made by the people and their increasing desire to use or utilize such resources. Should they not then at least have the privilege of saying in what manner the water right shall be developed? I have reference only to the value made by the people as a whole and not to the value added to the natural value by individual labor or effort. The individual right to this latter will hardly be questioned.

Any systematic development of water resources must include mining and navigation. The question of hydraulic mine tailings has been the cause of almost endless litigation in California. The interests of this State in river navigation where it will be affected by the use of water above navigation may, in years to come if not now, be greater than that of mining.

There comes under navigation the use of certain streams for logging. I know of a stream on which the logging interests are dominant through earlier use, at the expense of irrigation interests. It may be in this particular case that the logging interests should have the superior right—that the stream in that way yields a greater service to the State; but it may not, and we can conceive of a stream being held for logging purposes when it would be of infinitely greater value to the State as an irrigation stream.

Other water resources are artesian supplies and pumping from wells and streams for irrigation. Considerable has been done by the United States Geological Survey in investigation of artesian-well possibilities by study of the geological formations. Earlier bulletins by Russell and a later water-supply paper by Waring are valuable for reference in this connection.

WATER RESOURCES IN THEIR RELATION TO FORESTS.

Much has been said in the last few years of the value of forests in keeping up the summer flow of streams and thus benefiting both irrigation and power development. The radical supporters of forestry conservation will tell us that it hardly admits of argument. It certainly looks plausible, and yet you will find a great many of the hydraulic engineers of the country, if not indeed a large majority, of the opinion that the value of forests in preserving stream flow is very questionable.

Col. H. M. Chittenden of the United States Army Engineers, in a carefully prepared paper read before the American Society of Civil Engineers last year, refuted many of the arguments of the radical forestry advocates.

Mr. John R. Freeman, one of the most eminent engineers in New England, in an address before a meeting of engineers to consider conservation of national resources, said to his personal knowledge no perceptible change had taken place in New England streams from deforestation within his lifetime nor, so far as the available records show, since deforestation began.

Prof. Willis L. Moore, Chief of the United States Weather Bureau, in a carefully prepared report on The Influence of Forests on Climates and Floods, which was printed by direction of the Committee on Agriculture in the House of Representatives, states that the high waters in our rivers are not higher and the low waters are not lower than formerly, but, on the contrary, there appears to be a tendency in late years toward a slightly better low-water flow in summer. He, like most of the meteorologists, believes that the broken, cultivated, permeable soil is equally as good a conserver of rainfall as the forest area itself, and weather statistics favor the opinion of those who question the value of forests in preserving stream flow.

The following comparison of streams from forested and nonforested areas is from data prepared by John C. Stevens of Portland, Oreg., who was at the time assistant engineer of the United States Geological Survey, in charge of hydrographic investigations in Oregon and Washington:

A standard measure of the uniformity of flow is a very difficult thing to secure. For want of a better standard we may take the ratio of the maximum to the minimum discharge as the measure of uniformity. To show how it varies on different streams and under different conditions of forestation we will select a few streams in groups of two that drain both a forested and nonforested area and have nearly the same climatic conditions. As the intention is to show only relative conditions of flow, a single year's record is sufficient if simultaneous on the streams compared.

We will take for our first pair of streams the Donner and Blitzen River which flows into Harney Lake from the south and the Silvies River which flows into the same lake from the north. The Donner and Blitzen River drains the western slope of Steins Mountain and the watershed is without forest of any kind. The Silvies River, as the name implies, is quite heavily forested and it drains the southern slope of the Blue Mountains. The records of 1909 on both streams have been used. The highest discharge on Silvies River is 125 times the minimum flow and is in strong contrast to the even discharge of Donner and Blitzen River, whose maximum is less than 12 times the minimum.

We will take for our next pair of streams two which drain opposite sides of the Sierra Nevada Mountains in central California. Kings River drains the western slope and its entire area is heavily forested. Owens River drains the eastern slope and it is practically without forest of any kind. The soil of both is of granitic origin and the topographic features are not different. The rainfall on the Kings River drainage is a great deal more than on Owens River. On this account one would expect Owens River to present some of the features of arid region streams, but this does not appear to be the case. The discharge for 1906 has been used for both streams. The maximum discharge of Owens River is only 5 times the minimum while the maximum discharge of Kings River at the same time was 130 times the minimum discharge. The contrast is most striking and is all the more significant because the chief physical difference is that of difference in forest con-